# HOME HEATING WITH ELECTRICITY

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MORE THAN 700,000 American homes were heated electrically by the end of August, 1960, according to Electric Heat and Air Conditioning Magazine. An Illinois Farm Electrification Council survey revealed that more than 6,000 Illinois homes were heated electrically by January, 1961.

A University of Illinois student, reporting on 62 farm families who heat their homes electrically, found the users enthusiastic. None of the users had any general criticism of his electric-heating facilities. Small criticisms usually concerned installations in remodeled homes where there was not enough insulation or where the equipment was improperly placed.

## ADVANTAGES AND DISADVANTAGES

Some of the advantages claimed for electric heat compared to other types of heating systems are: lower installation costs, no fuel combustion, reduced fire hazard, no chimney, no space required for fuel storage, complete room by room heat control, no noise or moving parts, and little or no service or maintenance cost. For heat-pump type of systems, one unit supplies year-round temperature control.

Electric-heating systems have three disadvantages. There is no heat if the power fails. This is true for all automatic-heating systems operated by electricity. Humidity control is required in most kitchen and bath areas. And these systems require more insulation than conventional systems.

## COSTS OF INSULATING, INSTALLING, AND HEATING

Most power suppliers in Illinois will, upon request, give expert help to home owners interested in installing electric heat. Many will estimate the annual heating cost, recommend experienced installers, and inspect the system after it is installed.

Annual heating costs depend upon many factors — severity of winters, exposure of home to winds, degree of room temperature maintained, type of home construction, and quality and amount of insulation installed. These factors, of course, apply to all heating systems. A well-insulated house, equipped with storm windows and storm doors, is essential for electric heating. Power suppliers do not recommend electric heating for uninsulated homes. Where installations have

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been made contrary to recommendations, heating costs have been excessive.

Heating costs also vary with the unit cost of electric energy. The cost of electricity for heating in Illinois ranges from about 1 to 2 cents per kilowatt hour. There are two types of electric-heating systems — resistance-type electric units and heat pumps. Resistance heaters may be baseboard or wall heaters, or cables in the ceiling.

Annual costs for heating with electric units vary from 18 to 23 cents per square foot of heated area in the northern part of the state and from 10 to 18 cents in the southern portion (Fig. 1).

### Resistance-type units

The cost of insulation for and installation of an electric-heating system depends on the local costs of materials and labor. Naturally, these costs are not uniform throughout the state. A Chicago Mortgage Bankers Committee has compiled figures (supplied by an electric gas and utility company) that show the comparative costs of installing a gas hot-air system and an electric baseboard system in a 1,000 to 1,100 square-foot house. These figures are for the Chicago area.

| | Gas hot air | Electric baseboard |
|---|---|---|
| Wiring | $ 40 | $ 300 |
| Gas piping | 45 | ... |
| Chimney | 65 | ... |
| Heating equipment installed | 700 | 300 |
| Insulation | 125 | 325 |
| Storm sash and doors | 300 | 300 |
| Total | $1,275 | $1,225 |

The cost of installing gas heating in rural areas should also include the cost of a gas tank. The estimated cost of a 500-gallon tank is $300. The cost of installing a gas hot-air system in these areas would thus be $1,575 as against $1,225 for installing an electric baseboard system.

The costs of insulating for and installing electric heat are somewhat lower in the Shelby county area than in the Chicago area. In this county, costs for resistant electric heat run about $1 per square foot of living area or $1,000 for a 1,000 square-foot house. In the Clinton county area, installation of ceiling-cable heating systems costs about 50 cents per square foot of heated area and baseboard heating systems about 65 cents per square foot. The estimated cost of insulating for electric heating is 30 cents per square foot.

### Heat-pump systems

The cost of installing an electric heat-pump system (a combination heating and refrigerating system) is higher than the cost of installing resistance-type systems, but this system is more economical to operate. The cost, however, is comparable to the total cost of installing equipment for winter heating and summer cooling.

The estimated yearly cost of heating a home with an air-source heat pump is about 16 cents per square foot; the cost of heating a 1,000 to 1,100 square-foot house in the northern part of the state would thus be about $170 per heating season. For a home of the same size and in the same location heated with a water or ground source of heat, costs are about 11 cents per square foot or about $115 per season.

In the Clinton county area, a five-room-and-bath farm home of frame construction, having 1,250 square feet of living area, 6 inches of insulation in the ceiling, 3⅝ inches in the walls, storm doors and windows, was heated and cooled from October 1957 to October 1958 for $157.33. The cost for a corresponding period in 1958-59 was $179.78. The higher 1958-59 costs reflect the difference between the

1957-58 and 1958-59 seasons. The cost of this heating and cooling unit completely installed was about $2,000.

#### Insulation

Architects, engineers, and power suppliers recommend more effective insulation for electrically heated homes than for other types of heating systems. Costs for insulation may be two or three times that of conventional insulation. However, the savings in heating costs and increased winter and summer comfort offset the difference in costs. It may be argued that if insulation of the type installed in electrically heated homes were installed in homes heated by gas, coal, or oil, the cost of heating with these competitive fuels would be proportionately lower than present costs. However, the need for combustion of air limits the degree of tightness advisable with flame heating.

## ELECTRIC-HEATING SYSTEMS

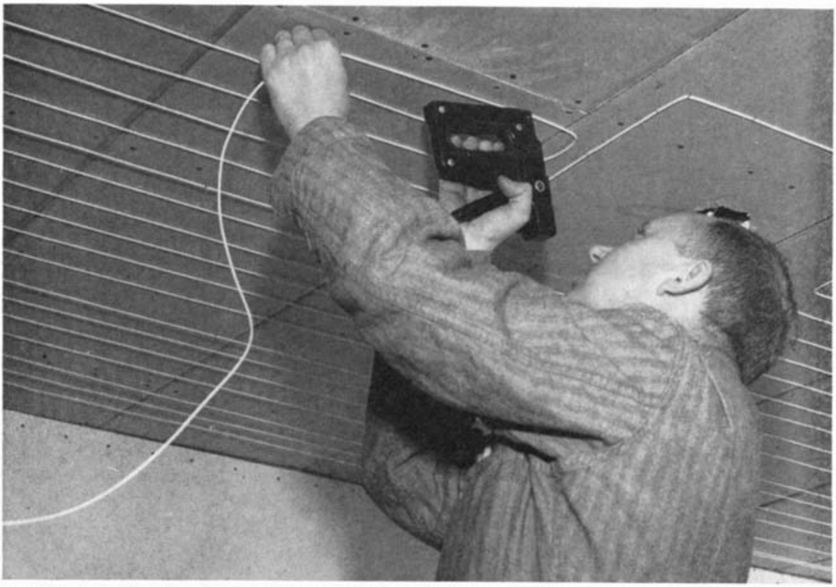
There are three ways of heating electrically — by radiation, convection, and conduction. For example, the sun heats the earth with radiant energy. The rays of the sun do not heat the atmosphere as they travel to the earth, but heat only the objects they strike, such as cloud formations, earth, buildings, and so on. Convection heating is the heating of objects by the movement of fluids such as air or water with temperatures higher than that of the fluids surrounding the objects. Conduction heating, as the name implies, is the conduction of heat through materials. For example, if a poker is placed in a flame, heat will be conducted through the length of the metal and a sensation of heat will be felt at the end of it.

### Resistance Heating

Three types of heating systems are used for room-controlled resistance heating. They are ceiling cables, wall panels, and baseboard heaters.

#### Ceiling cables

Heating cables are fastened to the ceiling (Fig. 2). They can be either covered with plastering or installed in dry wall construction. The temperature of the ceiling cables is maintained at a low level, about 100° F., and heat is transmitted to the room by radiant energy. This energy warms the floors, furniture, walls, and occupants.



**Plaster covers electric-heating cable applied to the ceiling of this room. A thermostat regulates the room temperature. The entire ceiling is heated to a relatively low temperature of about 100° F. when the system is operating. (Fig. 2)**

### Baseboard heaters

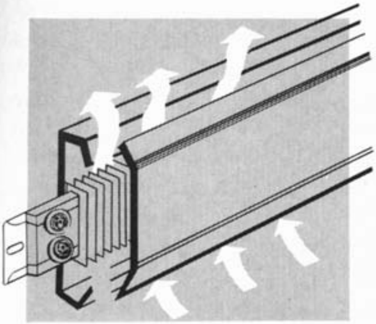
Baseboard heaters (Fig. 3) are mounted on the inside walls in place of the customary baseboard trim. Because they heat both by radiation and convection, they are effective in keeping floors, walls, and windows warm, and the room comfortable.

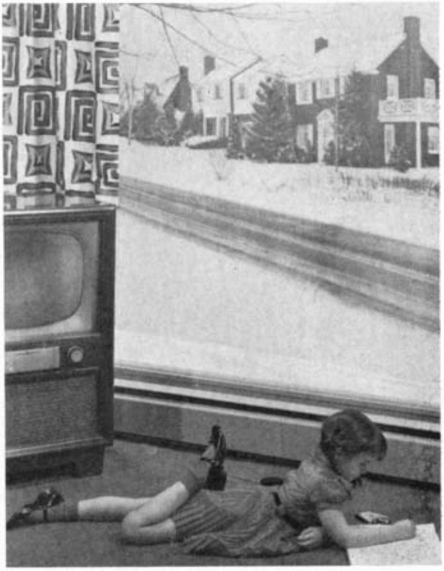
### Wall panel heaters

Wall panel heaters are units having surfaces of glass or metal or heating coils behind a protective grill (Fig. 4). Heating units are fused to the glass or metal surface of the panels. The units are mounted on the exposed walls of the room and the room is heated by radiation and convection.

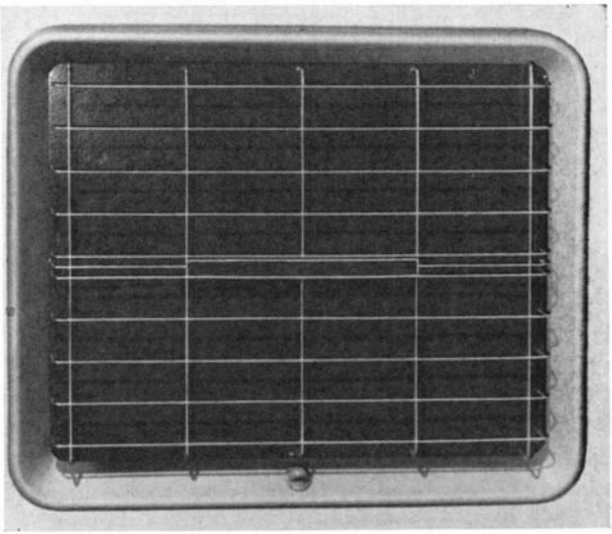
### Fan heaters

Some heaters have a small fan that circulates the heated air. This type is often used where large heating capacity is required occasionally, as in basements, laundry rooms, or workshops. Because of the fan,





(*Right*) the customary baseboard under this window is replaced by an electric resistance-type heater. Warm air rises in front of the exposed window and outside walls of the house. The warm air circulates through the room warming the entire area. Radiant heat from the baseboard helps keep the floors warm and comfortable. Drapes over the window should not cover the heater so they can be closed on cold days and nights. See cutaway drawing of heater *(top, left)*. (Fig. 3)

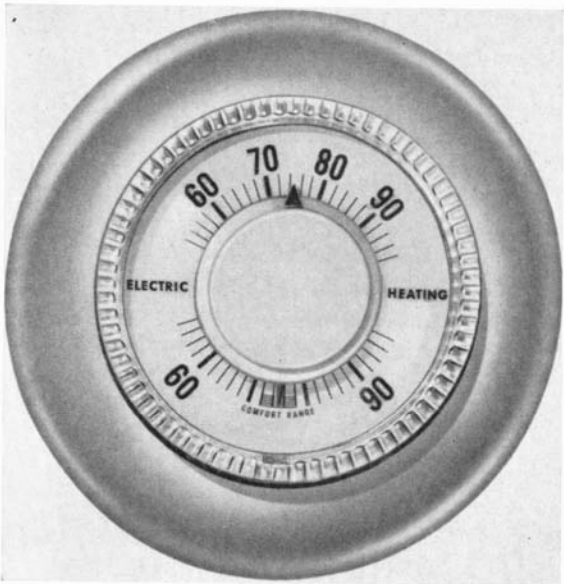


Resistance type of heater protected by metal grill is mounted on exposed walls of the room. The room is heated by radiation and convection. Units can be thermostatically controlled to give separately heated areas.
(Fig. 4)

these heaters create some slight noise. The ceiling cables, wall panels, and baseboard heaters are quiet and contain no moving parts.

**Thermostats**

Thermostats can be used to control the temperature of individual rooms (Fig. 5). This is one of the major advantages of an electric-heating system over conventional hot water or warm air heating systems. Each room has its own heating system and is controlled by its own individual thermostat.

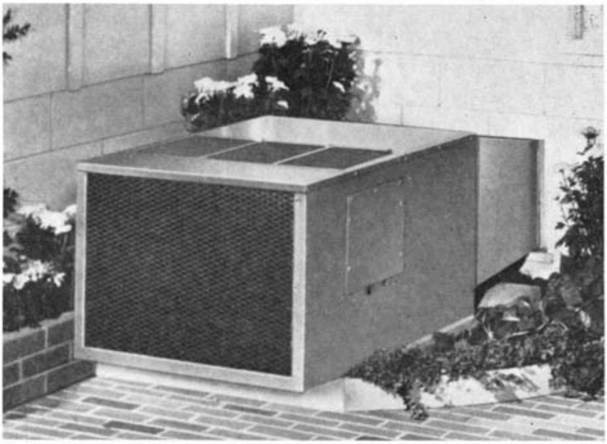


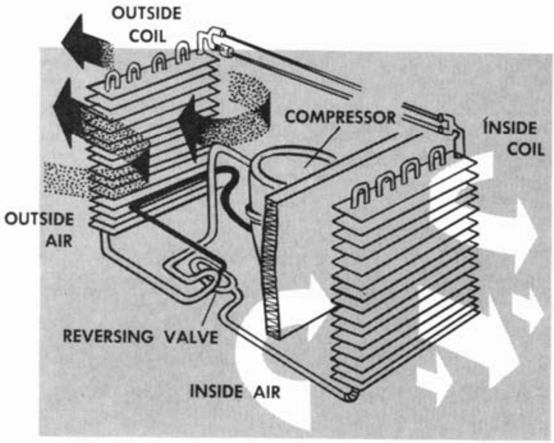

The room thermostat should be mounted on an inside wall of the room away from cold air drafts and heat sources. (Fig. 5)

## Heat-Pump Heating

The heat pump is, in effect, a reversible refrigeration unit. In the winter, it extracts heat from the outside air, ground, or well water, and conducts the heat into the home. In the summer, it reverses the process and removes heat from the house to the outside. Heating and cooling is controlled automatically by a thermostat to provide year-round indoor climate control. The heat pump can be placed in the basement, attic, or utility room with connecting metal ducts used to pipe the conditioned air to the various rooms. There is a trend toward placing the heat pump outside the home (Fig. 6) to reduce noise level and provide more living space.

One of the latest types of heat pumps is mounted outside the house on a concrete slab. It automatically controls the home temperature to the desired degree, cooling in summer and heating in winter.
(Fig. 6)






Schematic sketch of above heat pump.

## Electric Furnaces

The electric furnace is similar to a conventional flame-type hot-air furnace except that electric resistance-heating units are the source of heat. Electric furnaces are more compact than flame-type and, because they do not require a flue or vent, can be placed in the basement, attic, closet, or utility room. Some models feature a modulator that varies the heat input to the structure as weather conditions require. Central electric air-conditioning can easily be added to electric furnaces to provide a year-round system.

# INSULATION

Satisfactory and efficient electric heating depends on proper heating-system design, competent installation of equipment, and proper and adequate insulation. Effective insulation of the building will save on both the cost of heating equipment because less heating capacity needs to be installed and on the annual heating cost. Moreover, the effectively insulated house will be cooler in summer, will require less air conditioning capacity, and will be cheaper to heat and cool.

The effectiveness of insulation is measured by its thickness, type or kind, density, and method of installation. Various types of materials have different insulation values. One method of determining the comparative value of insulation is to compare the resistance (R) values[a] of the materials. Resistances (R) in this case are relative values; the higher the value, the better the effect. Some comparative values for insulation materials, as reported by the American Society of Heating, Refrigeration, and Air-Conditioning Engineers, are given below.

| Blanket and batt materials | *R value* | Loose fill materials | *R value* |
|---|---|---|---|
| Mineral and glass | 3.70 | Macerated pulp or paper | 3.57 |
| Cotton fiber | 3.85 | Mineral wool | 3.33 |
| Wood fiber | 4.00 | Sawdust or shavings | 2.22 |
| | | Vermiculite-expanded | 2.08 |
| | | Wood fiber | 3.33 |

[a] Resistance values given above are for materials 1-inch thick. These values will double for 2-inch material, triple for 3-inch material, and so on. The values are based on specified standards of density or weight of the insulation.

The insulation value (R) for a 4-inch thick (normally actual dimension 3⅝ inches) mineral wool blanket or batt would be $3\frac{5}{8} \times 3.70 = R$ R = 13.41.

The National Mineral Wool Association has announced a new method of rating the value of insulation based on resistance (R) factors as outlined above. Manufacturers of mineral wool insulation material, members of the above association, have agreed to stamp the resistance (R) value of the insulation on the shipping carton and on the insulation blanket or batt.

The loose fill type of mineral wool will be packaged in bags marked with required installed densities, thickness, and corresponding area coverage per bag required to meet a standard ceiling-installed resistance of R-19 and standard wall-installed resistance of R-11, and floor resistance of R-13. These values of insulation for ceiling, walls, and floor over unheated spaces are the National Mineral Wool Association's recommendations for electrically heated and air-conditioned homes.

### Ceilings

Ceiling insulation should be installed after wiring and plumbing are completed. Loose fill or blown insulation should adequately cover plates, cabinet recesses, and all other openings to heated areas. Insulation should be protected from wind or ventilation dispersion. When an electric ceiling-heating cable is installed, 8 to 10 inches of insulation having an R value of 24 to 30 are recommended by Illinois power suppliers.

### Walls

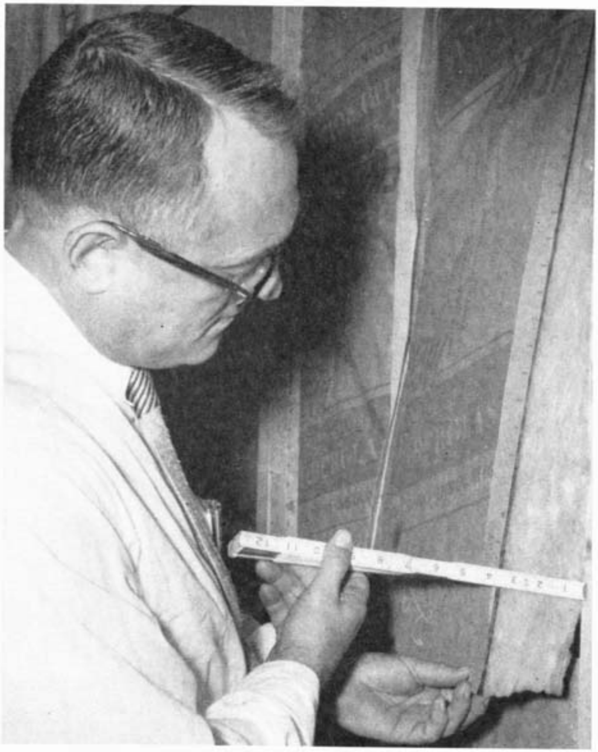
For new homes, Illinois power suppliers recommend a good quality blanket type of insulation. The insulation should be full wall thickness, should fill all cavities, voids, corners, and partitions in outside walls (Fig. 7). The insulation should be installed after plumbing and wiring have been completed. The resistance value of the material should be R-11 to R-13.

If loose fill insulation is used, the "double blow" method should be used where the vertical space to be insulated is more than 4 feet high. The "double blow" method requires blowing insulation from both top and bottom of wall cavity until the required volume and density of material is applied. Holes should be drilled in wall sections before insulation is applied and a plumb bob should be dropped into the holes to check space below for obstructions and a flexible steel rule used to check for obstructions above holes (Fig. 8).

### Floors

Four-inch blankets or equivalent insulation with a resistance value of R-13 should be installed under the floor between joists above a ventilated crawl space. Two inches or more of insulation should be installed under floors over unheated basements. The insulation should be sealed at the ends of floor joists to prevent air infiltration or blow-through. Insulation should be placed under or around pipes and electric wiring. Be sure to maintain the required thickness.

Waterproof 2-inch perimeter board-type insulation should be installed around the edge of a concrete slab floor to reduce heat conduction from the floor to the outside of the building. The insulation should also extend 2 feet horizontally under the slab or 2 feet vertically down the inside of the foundation wall.



Insulation should fill the space between the studs on exposed walls. This insulation is 3⅝ inches thick. It is stapled to the studs to hold it in place. The inside covering serves as a vapor barrier that prevents moisture condensation in the insulation during cold weather. For an additional and a complete vapor barrier, a .002-inch polyethylene film can be used to cover the inside wall before the rock lathe or wall board is mounted. (Fig. 7)

This workman has removed siding and is drilling a hole so that insulation can be blown into the wall under the window. He will probe the wall for obstructions that might prevent entrance of insulation before he begins the filling operation. (Fig. 8)

### Windows and doors

Spaces around window and door frames should be packed with caulking cotton to reduce infiltration and blow-through to a minimum.

Effectively sealed double glazing should be used throughout the house. Wood sash windows have a lower heat loss than metal sash and condensation is less troublesome. A window, even with a storm window installed, has eight times the heat loss of a well-insulated side wall.

### Fireplaces

The fireplace should preferably be placed on an inside wall to reduce heat loss. It should be equipped with a tight-fitting damper. The opening can be fitted with heat-resistant glass doors to lessen further the heat losses by exfiltration.

### Vapor barrier

A vapor barrier should be used to prevent moisture accumulation in the insulation. The vapor barrier for blanket or batt type of insulation should be on the side of the material next to the warm inside wall, ceiling, or floor. Polyethylene, asphalt, glossy asphalt-coated paper, and metal foil are suitable vapor barrier materials.

In new homes, an effective vapor barrier may be secured by covering the inside insulated walls with .002-inch polyethylene sheets before rock lathe or wall board is applied (Fig. 9). When a vapor barrier is installed, the number of joints should be held to a minimum. Precaution should be taken to prevent damage to the vapor barrier during or after installation. Joints between barriers should be made over wall studding or joists and should be lapped at least 2 inches. Vapor-barrier sealing tape is available to seal joints in barriers and breaks around pipes and wiring-outlet boxes. The vapor barrier for slab floors should be placed under the concrete. Polyethylene sheets .006-inch thick may be used as the vapor barrier.

The ground surface in a crawl space under the house should be sealed with a long life vapor barrier of either a 55-pound asphalt saturated roll or .004-inch polyethylene plastic film. The roofing paper should be lapped 6 inches and the plastic film 2 or more inches, but neither should be sealed.

Vapor barriers for existing homes may be secured by using paints on the inside surfaces. Aluminum paint with spar varnish as a vehicle, some emulsion paints specifically designed as sealers, primer sealer plus enamel paint, and rubber-resin lacquer types of paints may be used to provide a vapor barrier. Two or 3 coats are necessary.

Polyethylene applied over insulation provides an effective vapor barrier. The material covers windows and outlets; openings are cut after application is completed. Full wall length polyethylene sheets are used to keep breaks in vapor barrier to a minimum. (Fig. 9)

**Ventilation**

Areas above insulated ceilings should be vented to the outside to provide adequate air circulation above the insulation. One square foot of net vent area should be provided for every 300 square feet of insulated ceiling area. If the vents have louvers or are screened, 2 square feet of vent area for each 300 square feet of ceiling area should be provided. The vents should be uniformily and equally spaced to provide good air circulation above the insulation. For kitchen and bath low-velocity exhaust fans controlled by humidistats should be set at about 50 percent. The fans should have an air-carrying capacity of 150 to 200 cubic feet per minute. The outlet of the fans should be vented to the outside of the house, not into the attic, and the vents should be provided with an effective back-draft damper.

A cross-section drawing of this house illustrates the location of insulation. (Fig. 10)

## ADDITIONAL SOURCES OF INFORMATION

1. **How to Insulate Your Home for Electric Heating**
   National Mineral Wool Association
   2906 American Building
   Rockefeller Center
   New York 20, New York

2. **Electric Home Heating**
   REA Bulletin 142-1, Revised 1960
   Rural Electrification Administration
   U. S. Department of Agriculture
   Washington 25, D. C.

3. **Heating, Ventilation, Air-Conditioning Guide, 1959**
   American Society of Heating and Air-Conditioning
   Engineers, Inc.
   62 Worth Street
   New York 13, New York

4. **Manual for Electric House Heating**
   Publication No. HE 1-1957
   AIA File No. 30-C-44
   National Electrical Manufacturers Association
   155 East 44th Street
   New York 17, New York

*This circular was prepared by H. H. Beaty, Professor of Agricultural Engineering. The author gratefully acknowledges the assistance of the Electric House-Heating Committee of the Illinois Farm Electrification Council for supplying some of the information and some of the illustrations used in this circular and for its many helpful suggestions.*

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